

tip 132 defining a cavity 134 is shown in Fig. 7g. Rivet 130 displaces less material and requires less axial force to plunge into work pieces. Alternatively, as shown in Figs. 7h and 7i, rivets 140 and 150 define respective bores 142 and 152 through the lengths thereof. Rivets having holes, cavities or bores typically deform during the friction plunge welding process yet may hide flash produced during riveting. For example, referring to Fig. 8, the tip 132 of the rivet 130 may deform such that the tip 132 is forced back in the opposite direction to the riveting direction and the cavity 134 widens to provide a mechanical lock in addition to the metallurgical bond produced during the riveting process.

### REMARKS

The drawings have been objected to for lack of appropriate reference numerals in Figs. 5, 7f, and 9d. The proposed drawing corrections are submitted herewith. Approval of the drawings is respectfully requested.

The specification is objected to for a typographical error in paragraph 37. This error has been corrected by amendment.

Claims 1-4, 6-9, 11-17, 25, 26, and 28-30 stand rejected under the 35 U.S.C. § 102(e) for anticipation by U.S. Patent No. 6,213,379 to Takeshita et al. Claims 1-4, 7-9, 18, 21, 23, 25, 26, 28, and 29 stand rejected under 35 U.S.C. § 102(e) for anticipation by U.S. Patent No. 6,227,433 to Waldron et al. Claim 10 stands rejected under 35 U.S.C. § 103(a) for obviousness over the Takeshita et al. patent in view of WO 99/39861 (Midling et al.). Claim 5 stands rejected under 35 U.S.C. § 103(a) for obviousness over the Waldron patent in view of U.S. Patent No. 3,477,115 to Martin et al. Claims 12-17 stand rejected under 35 U.S.C. § 103(a) for obviousness over the Waldron patent in view of U.S. Patent No. 5,460,317 to Thomas et al. Claim 6 stands rejected under 35 U.S.C. § 103(a) for obviousness over the Waldron patent in view of U.S. Patent No. 5,769,306 to Colligan. Claim 19 stands rejected for obviousness over the Waldron patent in view of U.S. Patent No. 6,067,839 to Xie. Claim 20 stands rejected for obviousness over the Waldron et al. patent in view of U.S. Patent No. 6,050,474 to Aota

et al. Claims 12, 13, and 22 stand rejected for obviousness over the Waldron et al. patent in view of U.S. Patent No. 4,676,707 to Cearlock et al. Claims 24 and 27 stand rejected for obviousness over the Waldron et al. patent in view of U.S. Patent No. 6,344,117 to Enomoto et al. Claims 31 and 32 have been indicated as containing allowable subject matter.

Applicant respectfully traverses the prior art rejections for the following reasons.

The present invention is directed to a method of joining a pair of metal components by friction plunge riveting. According to this method, a metal rivet is plunged into a pair of overlapping metal components. The first metal component has an exposed continuous surface. No hole is predrilled in the first metal components to assist in plunging the rivet into the pair of components. The hardness of the metal rivet is substantially similar to the hardness of at least one of the two components being joined. Despite the middle rivet having a hardness that is substantially similar to the hardness of at least one of the first and second components, the metal of the rivet and the metals of the first or second components is plastically deformed.

Applicant respectfully traverses the rejections based on the Takeshita et al. patent either alone or in combination with Middling WO '861 for the following reasons. The Takeshita et al. patent describes conventional friction plug welding in which a hole is made in an article to be welded and a plug is inserted into the hole and rotated to friction weld the plug to the article. See column 2, line 32; column 4, lines 41-49; column 6, lines 25-27; column 10, lines 23-25; and claim 1. In all instances, a hole is drilled in the upper component into which the plug is inserted and then friction welded. This feature of requiring a hole in the first component is distinguished from the present invention at paragraph 3 of the specification.

Claim 1 of the present application requires that the first component have a "first exposed continuous surface". In other words, the first component does not include a hole drilled therethrough. Claim 29 also requires a system in which a first component being joined to a second component has a "continuous first exposed surface". Hence, in

both independent claims 1 and 29, a key distinction is set forth, namely, that the first component has a continuous exposed surface and does not include a hole therethrough or any other such pilot hole. Claim 25 has been amended to depend from claim 1 and constitutes a product produced according to the method of claim 1.

There is no teaching or suggestion in the Takeshita et al. patent that anything other a first component having a hole to initiate the process of inserting a plug into a pair of components is possible. The Office Action asserts that the Takeshita et al. patent discloses a rivet which "may be placed in a predrilled hole". This characterization of Takeshita et al. is incorrect. The predrilled hole is necessary in all circumstances where the hardness of the plug is the same or softer than the hardness of the components. See column 4, lines 42-49. Hence, the Takeshita et al. patent does not anticipate claims 1-4, 6-9, 11-17, 25 (as amended), 26 or 28-30.

In the obviousness rejection of claim 10, the Middling WO '861 is relied upon for its teachings to preheat a tool prior to insertion into components. WO '861 does not account for the deficiencies of the Takeshita et al. patent; namely, to weld into a first surface which is continuous without a predrilled hole. Accordingly, claim 10 also defines over the prior art of record.

The remaining rejections are based upon Waldron et al. patent alone or in combination with secondary references. These rejections should be withdrawn because the Waldron et al. patent fails to teach the limitations of claims 1 and 29 of the hardness of the rivet being substantially similar to the hardness of at least one of the first and second components. The Waldron et al. patent is directed to a method of friction welding a fastener to workpieces where the fastener has the same or different melting point from the workpieces. The Office Action equates the disclosure of similar hardness required in the present claims with the similar melting point disclosed in the Waldron et al. patent stating that "the components have the same hardness (same material, same melting point) as the plug (column 3, lines 1-4)." However, such an equation of melting point with hardness is incorrect.

The present application recognizes the importance of the hardness of the rivet which is being plunged into a pair of components. Melting point and hardness are two different features. For example, a rivet may have the same melting point as a pair of components into which the rivet is to be driven. However, the rivet could be made harder than the components by freezing the rivet before driving it into the components. By way of further example, there are several aluminum alloys which have the same melting point yet have different hardness. An aluminum alloy which has been solution heat treated (e.g. to achieve T4 temper) is softer than a fully aged aluminum alloy in the T6 temper. These alloys have the same melting point but the T6 temper alloy which is fully aged is harder than the T4 temper alloy. Again, melting point and hardness are not equivalent.

The Waldron et al. patent does not appreciate the importance of hardness to the plasticization that occurs in the present invention. The rivet having a hardness of at least as hard as the hardness of the metal components plasticizes at a rate the same as or slower than that of the metal components. No such effect is considered in the Waldron et al. patent. Hence, claims 1-4, 7-9, 18, 21, 23, 25 (as amended), 26, 28, and 29 define over the Waldron et al. patent.

With respect to the obviousness rejections of claims 5, 6, 12-17, 19, 20, 22, 24, and 27, secondary references do not account for the deficiencies in the Waldron et al. patent; namely, that the rivet has a hardness which is substantially similar to the hardness of at least one of the first and second components. Hence, claims 5, 6, 12-17, 19, 20, 22, 24, and 27 define over the Waldron et al. patent in combination with the Martin et al., Thomas et al., Colligan, Xie, Aota, Cearlock et al., or Enomoto et al. patents.

The following comments are directed to the patentability of certain of the dependent claims. Claim 3 requires that the final position of the pointed rivet tip rest within the second component. The Takeshita et al. patent only considers extending the rivet tip completely through both of the components. Although the tip is pointed, it does not come to rest within the second component. Hence, claim 3 further defines over the Takeshita et al. patent.

Claim 4 requires that the pointed rivet tip raise a portion of the second exposed surface. Again, the Takeshita et al. patent only considers the rivet tip extended out through the second component and thus cannot raise a portion of the second exposed surface. The Waldron et al. patent shows the rivet tip having a final position within the second component. However, there is no raised portion of the second exposed surface (the underside of the lower workpiece). Hence, claim 4 further defines over the Takeshita et al. and the Waldron et al. patents.

Claim 5 requires that the raised portion of claim 4 have a semispherical configuration. This rejection of claim 5 over the teachings of the Waldron et al. and Martin et al. patents fails because the Martin et al. patent does not show a raised portion of the second surface having a semispherical configuration. The Office Action points to Fig. 6 and column 2, line 15 to column 3, line 17 of the Martin et al. patent. In all the embodiments shown in the Martin et al. patent, the fastener resides within either the first or second components (Figs. 2 and 4) or within the third component (Fig. 6). In none of those instances does the fastener extend so far into the lowest component that a raised portion forms on an exposed surface of the lower component to form a semispherical configuration. While the welding zone within the components being joined may have a semispherical configuration, this does not indicate that any raised portion forms on the lower component, which is semispherical in configuration. Accordingly, claim 5 further defines over the prior art of record.

Claim 7 requires that the final position of the pointed rivet tip is flush with the second exposed surface. This feature is not taught or suggested by the Takeshita et al. or the Waldron et al. patents. Again, the Takeshita et al. patent only considers that the tip extends completely through the second component. The Waldron et al. patent only shows that the tip resides within the second component. Neither patent contains any suggestion to alter those arrangements. Hence, claim 7 further defines over the prior art of record.

Claim 8 is dependent upon claim 7 and further requires that the first and second components are held together between the clamp and a backing anvil where the

backing anvil has a planar surface against which the rivet abuts to maintain the rivet tip flush with the second exposed surface. The Takeshita et al. patent describes no such backing anvil and hence cannot anticipate or render obvious claim 8. The Waldron et al. patent does show the use of a backing anvil (25). However, in no instance does it show that the backing anvil abuts against the rivet as it is driven into the second component to maintain the rivet tip flush with the second exposed surface. Accordingly, claim 8 further defines over the prior art of record.

Claim 13 requires that the rivet have a flange and lip which together define a recess for collecting flash between the rivet and the first exposed surface. The Takeshita et al. patent contains no such rivet with any means for collecting flash between the rivet and the first exposed surface. Hence, claim 13 further defines over the Takeshita et al. patent. With regard to the rejection of claim 13 based on the Waldron and the Thomas et al. patents, the Thomas et al. patent does not disclose a mechanism for collecting flash between the rivet and the first exposed surface. At best, the Thomas et al. patent teaches at column 9, lines 4-7 that the shoulder (26) shown in Fig. 13 prevents excessive dispersal of plasticized material being formed. There is no recess that collects flash between the rivet and the first exposed surface. At best, flash may collect beneath the shoulder 26 and in between the rivet and the interior of the first component. There is no collection of flash between the rivet and the first exposed surface. Accordingly, claim 13 defines over the prior art of record.

Claim 16 requires that the rivet include a bore which extends completely through the rivet. The Takeshita et al. patent discloses a bore that extends only part way through the rivet. There is no suggestion or teaching therein to extend the bore completely through the rivet. Hence, claim 16 further defines over the Takeshita et al. patent. The Office Action asserts that it would be obvious to include a central bore to remove excess material during friction bonding citing to the Waldron et al. and Thomas et al. patents. However, neither of the cited patents teach nor suggest such an arrangement. Any suggestion to provide a bore completely through the rivet would come

from the claim itself and such a rejection is inappropriate. Hence, claim 16 further defines over the prior art of record.

Claim 18 requires that a third metal component is joined to the second metal component by rotating and plunging another rivet into the third component and the second component. In this manner, two rivets are plunged into opposing sides of a stack of three components. No such arrangement is considered in the Waldron et al. patent and claim 18 is believed to define thereover. At the most, the Waldron et al. patent suggests at column 4, lines 33-38 that three or more workpieces may be joined, but the patent does not suggest that the joining could occur from opposing sides of the stack of workpieces.

Claim 19 further modifies claim 18 and requires that the third surface has a pilot hole into which the second rivet is positioned prior to plunging the rivet into the second and third components. The Office Action asserts that the combined teachings of the Waldron and Xie patents renders obvious this method. However, the Xie patent only teaches drilling a hole completely through a component prior to friction welding. The Xie patent adds nothing further to the Waldron patent which already considers that predrilling a hole may be necessary in situations where the melting points of the components are similar. Moreover, neither reference teaches or suggests driving a rivet into a stack of components from opposite sides of the stack or such friction plunge riveting from opposite sides of the stacks simultaneously. Hence, claims 19 and 20 further define over the prior art of record.

Claim 21 requires that the rivet head is removed following solidification of the friction weld. The Office Action asserts that claim 21 is anticipated by the Waldron patent which supposedly shows a fastener without a head in Fig. 6. However, the specification regarding Fig. 6 does not indicate that the fastener has been broken in any manner. Fig. 6 only shows a portion of the fastener as it is friction welded and not that the fastener head has been removed therefrom. Accordingly, claim 21 further defines over the prior art of record.

In view of the amendments to the specification and claim 25 and the proposed drawing changes, claims 1-32 are believed to define over the prior art of record

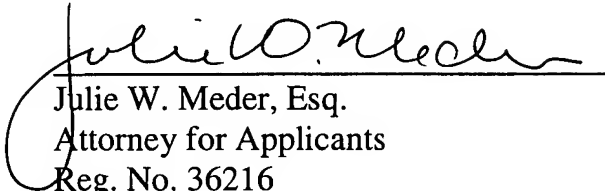
and all be in condition for allowance. Reconsideration of the rejections and allowance of claims 1-32 are respectfully requested.

Respectfully submitted,



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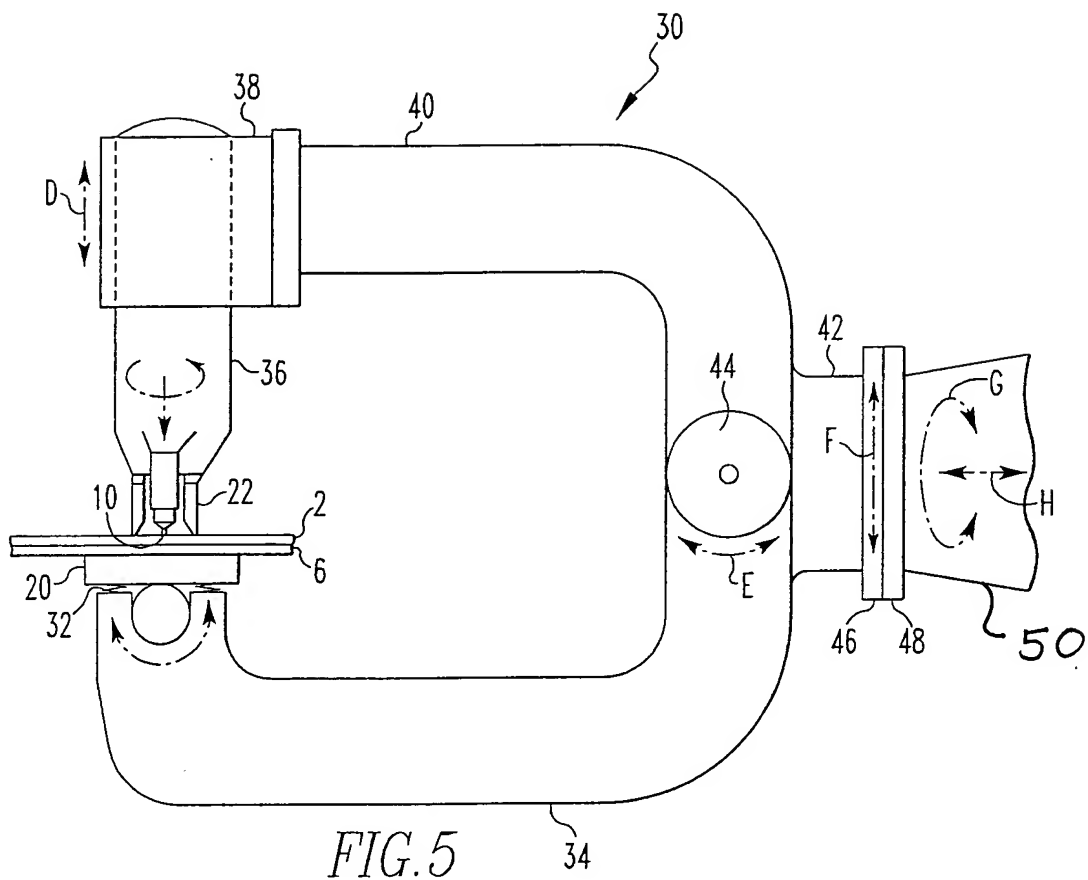
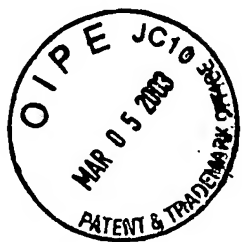
  
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**Marked-up copy of claim 25**

25. (Amended) A composite metal product [comprising:  
a first metal component having a first exposed surface;  
a second metal component underlying the first component; and  
a metal rivet extending from said first exposed surface into the second  
metal component, said rivet being friction welded to each of said first and second  
components, wherein the metal of said rivet has a hardness substantially similar to  
at least one of the first and second metal components] produced according to the  
method of claim 1.

**Marked-up copy of paragraph 37**

[0037] The rivet 10 shown in Fig. 10 is shown in detail in Fig. 7a. Rivet 10 includes slanted sides 72 which make an angle  $\alpha$  with the centerline L of the rivet 10, with  $\alpha$  being up to about 35°, preferably about 7° to about 25°. [On] One suitable diameter d of tip 12 of the rivet 10 is about 10 mm. Rivet 10 is shown as having a rounded tip, but the tip may also be planar. Other non-limiting examples of rivets are shown in Figs. 7b-7i. Rivet 80 shown in Fig. 7b includes a cylindrical portion 82 that steps down to a first slanted side 84 which makes an angle  $\beta$  with the centerline L of the rivet 80 and to a second slanted side 86 which forms an angle  $\gamma$  with the centerline L of the rivet 80, with  $\beta$  being greater than angle  $\gamma$ . As shown in Fig. 7c, rivet 90 includes an integral flange 92 and has a pointed tip 94. Rivet 100 shown in Fig. 7d is similar to rivet 10 except that rivet 100 has a tip 102 which defines a central opening 104. Another variation of rivet 10 is shown in Fig. 7e as rivet 110 which includes an integral flange 112 having sloping sides 114 and one or more helical groove(s) 116 defined in the surface. The helical grooves 116 assist in threading the rivet 110 into a work piece and act similar to a friction stir welding tool. Rivet 120 shown in Fig. 7f is similar to rivet 110 except that integral flange 122 has straight sides 124. A partially hollow rivet 130 (similar to rivet 80) with a tip 132 defining a cavity 134 is shown in Fig. 7g. Rivet 130 displaces less material and requires less axial force to plunge into work pieces. Alternatively, as shown in Figs. 7h and 7i, rivets 140 and 150 define respective bores 142 and 152 through the lengths thereof. Rivets having holes, cavities or bores typically deform during the friction plunge welding process yet may hide flash produced during riveting. For example, referring to Fig. 8, the tip 132 of the rivet 130 may deform such that the tip 132 is forced back in the opposite direction to the riveting direction and the cavity 134 widens to provide a mechanical lock in addition to the metallurgical bond produced during the riveting process.



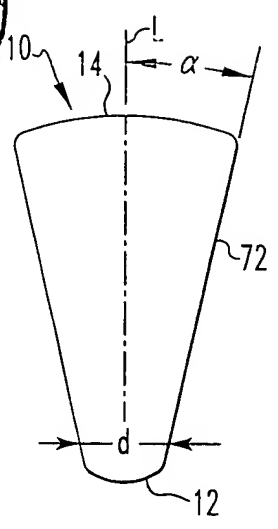


FIG. 7a

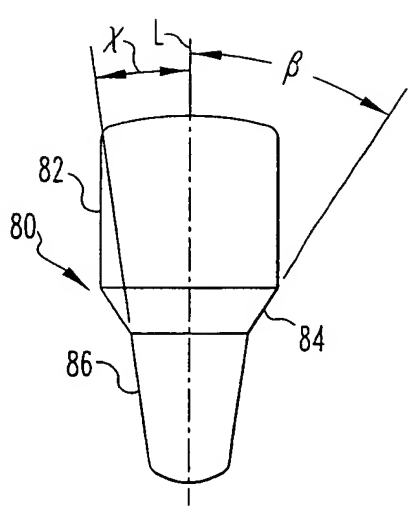


FIG. 7b

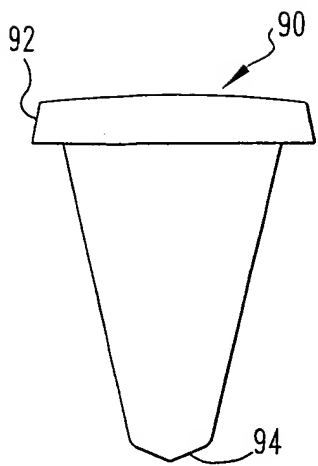


FIG. 7c

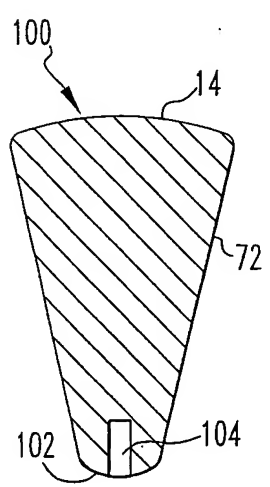


FIG. 7d

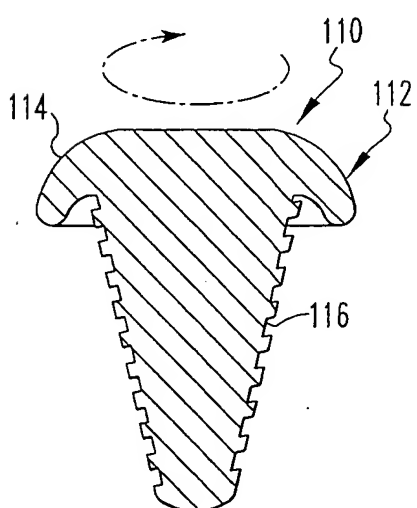


FIG. 7e

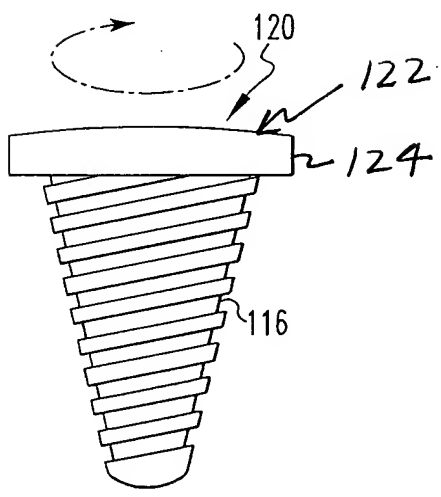


FIG. 7f

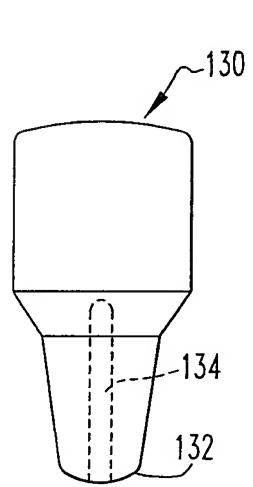


FIG. 7g

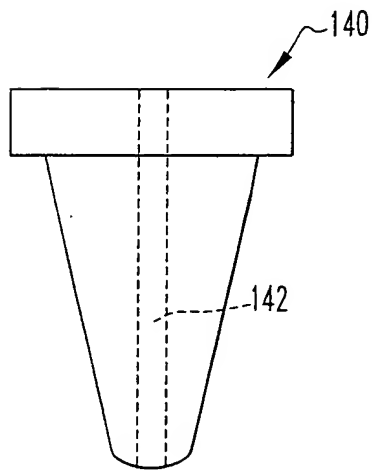


FIG. 7h

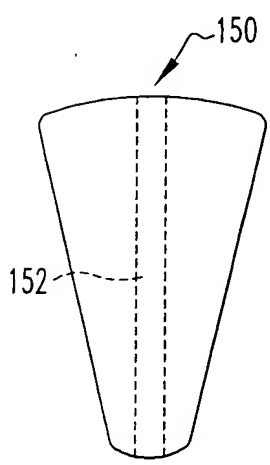


FIG. 7i

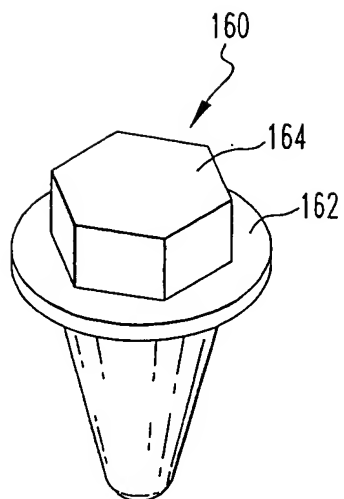


FIG. 9a

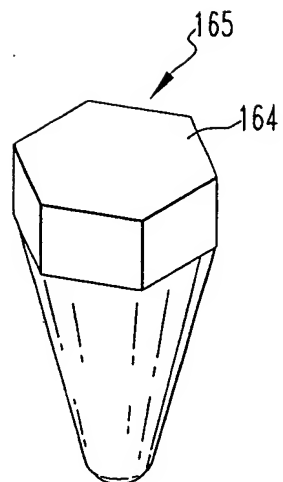


FIG. 9b

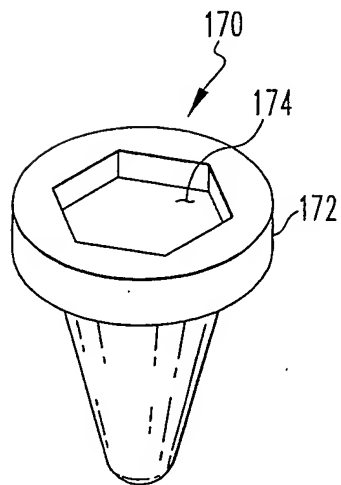


FIG. 9c

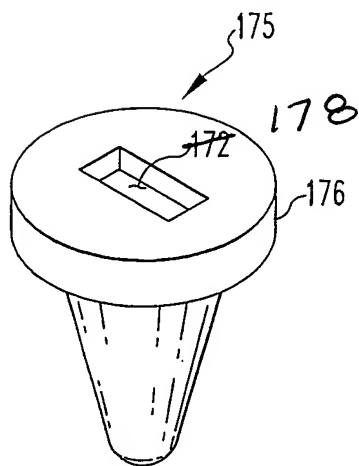


FIG. 9d